DYNAMIC ANALYSIS OF STEEL FRAMES SUBJECTED TO IMPULSE LOADS

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ABSTRAK

Beban impuls adalah beban yang tertakluk pada struktur dalam masa yang sangat singkat. Jenis beban ini biasanya dikaitkan dengan beban letupan, yang dihasilkan daripada tekanan ledakan dari letupan kimia. Respon struktur yang tertakluk pada beban impuls boleh dikaji melalui eksperimen dan pendekatan berangka *(numerical)*. Walaubagaimanapun, eksperimen memerlukan prosedur keselamatan yang sangat ketat dan kos yang tinggi. Oleh kerana itu, permodelan berangka *(numerical modelling)* adalah perdekatan alternatif yang boleh diambil. Jadi, kajian ini adalah untuk mengkaji respon stuktur bingkai keluli yang tertakluk kepada beban impuls dengan menggunakan unsur terhingga *(Finite Element)*. Salah satu objektif untuk kajian ini ialah untuk membangunkan satu kod finite *element* menggunakan OCTAVE untuk meramalkan respon stuktur bingkai keluli apabila menggunakan pelbagai beban impuls. Jadi, kertas ini membentangkan tentang analisis dinamik bingkai keluli apabila tertakluk kepada beban impuls. Analisa ini dijalankan menggunakan kaedah unsur terhingga *(Finite Element Method)*. Kod Unsur Terhingga *(Finite Element)* dibangunkan dengan menggunakan satu pengisian bahasa pengaturcaraan untuk mengkaji kelakuan dinamik bingkai keluli. Hasi; dari kod sumber yang dibangunkan akan disahkan dengan perisian unsur terhingga komersil, ABAQUS. Daripada kajian ini, perbezaan jenis sokongan mepengaruhi kelakuan dinamik bingkai keluli apabila stuktur tertakluk kepada pelbagai berat letupan di pelbagai jarak menentang.

ABSTRACT

Impulse loads are loading that are subjected on structures in a very short time. These types of loads are commonly associated with blast loads, which are generated from blast pressures from chemical explosions. The response of structures subjected to impulse loads can be studied using experimental and numerical approaches. However, experimental studies require stringent safety procedure and can be costly. Therefore, numerical modelling is an alternative approach, which is the aim of this study. This study is interested investigating the response of steel frames subjected to impulsive loading using finite element (FE) analysis. One of the objectives of this study is to develop a finite element codes using OCTAVE to predict the response of steel frames when subjected to various impulse loads. So, this paper present the dynamic analysis of steel frames subjected to impulse loads. The analysis is performed using finite element method. Finite element source codes were developed using OCTAVE, a programming language software, to investigate the dynamic behaviour of the steel frames. The results from the developed source codes are validated against the result from a commercial finite element software, ABAQUS, where satisfactory results are obtained. From this study, the types of support influenced the dynamic behaviour of the steel frames when subjected to different explosive weights at various standoff-distances

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LIST OF SYMBOLS

θ	Rotation
[M]	Global Mass Matrix
[K]	Global Stiffness Matrix
{F}	Global Load Vector
{U}	Displacement
$\{\dot{U}\}$	Velocity
$\{\ddot{U}\}$	Acceleration

LIST OF ABBREVIATIONS

FE	Finite Element
FEM	Finite Element Method
FEA	Finite Element Analysis
rc	Reinforced concrete
RK4	Rugge-Kutta 4^{th} Order
FD	Finite Differential

CHAPTER 1

INTRODUCTION

1.1 Background Study

Bombing and explosions are one of the easy ways for terrorist to commit the violence. All the attacks are usually for the terrorist to achieve and justify their blood act on the economic, social and political unfairness and sometime they inspired from the religious beliefs or spiritual principles. Over the past decade, this attacks have been caused thousands of death, damages to development and increased racism over different races, cultures and religions.

For the past decade, the bombing and explosions attack became worst year to year. For the recent bombing attacks in Sri Lanka on 21st April 2019 where the explosions is occurred in eight different location of churches and hotels in Sri Lanka. This attacks have been caused about more than 250 people died and more than 500 people were injured and damages to public buildings.

Usually, the iconic and public buildings is a target for the terrorist attacks. Most of the building have been built or are built without consideration of this unexpected event. All this incident raise the concern the whole world and researcher to study about the response of various structure subjected to impulse load (blast loading).

1.2 Problem Statement

The response of the structure can be studied by performed experimental and numerical approaches. However, experimental studies requires stringent safety procedure and costly. Therefore, numerical modelling is an alternative approach, which is the aim of this study. This study is interested investigating the response of the steel frames subjected to impulse loading using finite element (FE).

Other than that, to perform the numerical analysis, usually researcher will be used the commercial software that available in the market. However, the commercial software is restricted, having some problem with the licensing issues and sometimes costly to be used and learned for beginner designer. So, this study is focusing in develop the FE open source code using the open software to analyse the response of the steel frames subjected to impulse load.

1.3 Objectives

The objectives of this study are:

i. To develop a FE code using OCTAVE to predict the response of steel frames when subjected to impulse loads.

ii. To compare the develop finite element source code with ABAQUS.

iii. To investigate the response of steel frames subjected to different impulse loads and different boundary conditions using finite element method (FEM).

1.4 Scope of Study

The scope of this study:

i. This study is focusing on elastic analysis only.

ii. This study is analysed for different boundary condition which is simple-supported and fixed steel frames and also for different impulse loads.

iii. This study is identified the behaviour of steel frames subjected to impulse loads.

1.5 Significance of Study

The significance of this study are:

i. To provide an open source code software that focus on simple analysis of frames so that can be used for designer engineer.

ii. To provide a platform for the beginner designer and can be used for educational purposes to get more understanding for the fundamental of the FE analysis.

1.6 Summary

This thesis will contain of five chapters which in Chapter 1 shall discuss about the introduction of this study and give some overview about developed FE code.

Chapter 2 which is Literature Review will be discussed about some cases study, that almost similar to this study. It is also elaborate the different types of explosion, comparison between commercial software and develop source code.

Chapter 3 which is Methodology will be discussed on approach and frame work have been used in this study. It will cover the FEM of frames, two different time integration approach and other techniques that have been used for the analysis. The methodology will be discussed in detail in this chapter.

Chapter 4 will be shown and discussed the results from the developed FE source code using OCTAVE. This chapter also will be discussed on the validation with commercial software and verification other method.

Chapter 5 argue on conclusion of dynamic analysis of steel frames subjected to impulse loads. This is meaningful for the whole description of this project.

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